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Original Research

Analyzing the effect of Slipper cast and Circumferential wrap molding in the manufacture of insoles on ankle kinematics in patients with flexible flat foot

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ABSTRACT

In this study, the kinematic effect of two molding methods in the manufacture of foot orthoses on ankle joint was examined. The aim of this study was to determine a more beneficial method about ankle kinematics in the manufacture of insoles for people with flexible flat foot. Ten males aged 19 to 27 years, with normal BMI and normal gait pattern participated in this study, all of them had flexible flatfoot. Each person wearing special shoes on three situations: stepped without the insole, with the Slipper cast insole and Circumferential wrap method insole and in each situation completed a walk cycle. The kinematic data were collected and measured for each subject under three assumed positions by VICON motion analysis system. For comparison and analysis of three assumed situation, repeated measures test (ANOVA) was used. The results of this study show that the use of two molding method, had no immediate effect on reducing the average maximum eversion angle of the ankle. Eversion speed limit in the ankle was not affected by insole molding and no significant difference was observed. Compared to the situation without insoles, insole with the Slipper cast and Circumferential wrap molding method led to little difference in amplitude eversion. This study evaluated immediate effect of insoles. Two custom foot orthotics intervention did not lead to significant decreases in maximum eversion angle of ankle in the frontal plane.

Keywords: Flexible flat foot, Insoles custom fabrication, Molding method, Kinematic ankle.

Introduction

Flat foot is a common problem in children, adolescents and adults (Leung et al., 1998; Sokhangoui Y and M, 2006). Studies have shown that 60 percent of the population has a normal arch, 20 percent reduced longitudinal arch, and a 20 percent have increased longitudinal arch (Williams et al., 2001), and the last 40 percent had the most attention, because these abnormal structures leads to some degree of compensation in the mechanism of the lower extremities, and because foot is in contact with the ground during walking, the structural changes in it may lead to destroy the normal direction, and ultimately mechanical distortions of the limbs (Williams et al., 2001). Accordingly, many studies had done in this field to provide solutions for their treatment (Ckuckpaiwong et al, 2006; Sokhangoui and Asgari, 2004), Many specialists in rehabilitation physical medicine use secret insoles and foot orthoses as part of the rehabilitation process, to improve and increase foot performance and lower extremities, and for many other symptoms of motion systems (Springett et al., 2007). Many researchers introduced bracing as a means of controlling the speed and sequence of temporary movement of the subtalar joint and limb to restore the biomechanical connection with the normal level during the stance phase and as a nonsurgical treatment for flatfoot ortheses (Leung et al., 1998; Zifchock and Davis, 2008). But these orthosis are very various, so that, today varieties of orthotics such as modified shoes, the longitudinal arch supporting and the insoles used in shoe are used in the treatment of flexible flat foot (Leung et al., 1998). Success of these orthotics have been due to their ability to control movement of the hind foot (Zifchock and Davis, 2008). Foot orthoses may be constructed as prefabricated or specifically for individuals' personal needs (orders). According to numerous studies that evaluated the effect of custom and semi-custom orthotic foot control of some movement of posterior foot ,such as the maximum angle of the eversion, time and speed of eversion taken during walking and running, but a significant reduction of tool and mold not had been mentioned (Davis et al., 2008; Zifchock and Davis, 2008).

Given the high prevalence of dropped longitudinal arch and its undeniable effect on the mechanism of the lower extremities and its other complications despite numerous studies that foot orthoses and in particular insoles construction methods and different functions on the control of pronation have been made. It seems that the lack of sufficient evidence on current methods of molding of the foot requires more research compared the effect of two different impressions on foot kinematics. On the other hand, many studies based on individual reports to evaluate the success rate of orthotic molded versus non-molded orthotic been made in reducing symptoms (McCourt F., 1990; McCourt et al., 1994; Springett etal., 2007; Stell and Buckley, 1998), but the service inquiry and research of Drug and Health Technology Agency of Canada in 2009 stated that any research or clinical study different methods of casting with plaster bandages, compression molding with foam box or force plate technique has not been and in this context there is a lack of information and resources (Stell and Buckley, 1998). Given the approach, many methods have been used and offered for molding that among these two methods in this study, the method Slipper cast technique and Circumferential wrap are more prevalent and have more credit. Nevertheless the characteristics and biomechanical effects are still not fully understood and the proof of the results of this study about different molding methods, using appropriate molding methods will be helpful to orthopedic society and patients. The importance of this issue and that role can improve the symptoms of flat feet and also have the convenience of users of insoles. The aim of this study was to compare the two molding methods in the molding in the manufacture of insoles on ankle kinematics in patients with flexible flat soles of the feet.

Material and Methods

Participants

The study population consisted of 10 young men with flexible flat foot longitudinal arches (age: 1.42 ± 24.77 years; weight: 6.59 ± 56.15 kg; Height: 0.08 ± 176 cm) . From the population available to any person that the conditions and criteria for inclusion (normal BMI, flat flexible longitudinal arches with longitudinal arches index (AI) higher than 3.0, natural walking pattern) and with regard to the exclusion criteria from the study (a history of musculoskeletal diseases or neurological disorders or a history of surgery or lower extremity injuries, have a history of foot orthoses, and abnormal gait), a non-randomly and voluntarily were studied and evaluated.

Surface design

In this study three-dimensional motion analysis system with five VICON infrared cameras with 100 Hz for kinematic data collection have been used. For each subject for the Feet and Legs on each side of the body from an 8-marker collection with a diameter of 14 mm was used that the markers set 8 foot on the first and fifth metatarsal, and the posterior part of the heel bone. The leg markers on internal and external malleolus of ankle, tibia internal and external condyle of tibia surface anterior (between salience and malleolus) were placed. After completing written informed consent by participate in the test, examined by orthopedic expert and if he had all inclusion criteria to the test the entire process was described for each subject accurately before testing. Participants were asked to stand on a force platform and look forward for 2 seconds for static calibration. All analysis for the dominant foot (right foot) were performed. All stages of this test were done in one day and in the Biomechanics Laboratory of the University of social Welfare and Rehabilitation Sciences.

Two pairs of custom insoles for each person by an identical construction method and on a pre-prepared positive form, that form of a pair by Slipper cast, and another pair from Circumferential wrap molding had been obtained. It is worth noting that both orthotics were made and molded by an orthotics expert. After completing the molding process and preparing two pairs of negative mold slipper cast and circumferential wrap from each sample, then information of individuals on forms indicating a positive form on the negative mold was made. Again, to remove the other factors intervene in all the mold, preparing formwork and building both types of orthotics insoles was done by an expert. After preparation positive molds of any correction was not on them to minimize change the form of individual error rate on data formats. Then was prepared to made molds for the manufacture of foam on the texture of cotton socks pulled up to ensure uniformity in foot beds.

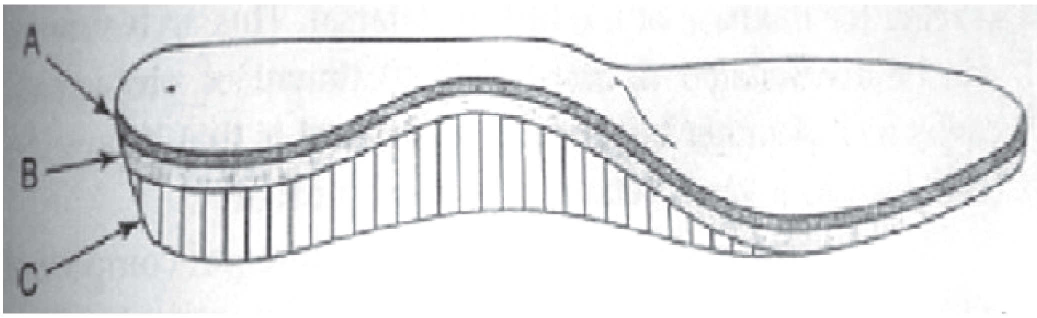

Figure 1. Various components forming the insole. Top Layer (A), shock-absorbing component (B), and supportive component (C) (Hsu et al., 2008).

Before making a decision about the type and amount of materials used in the manufacture of insoles, an upper layer of the surface of the connector head to foot were selected (Hsu et al., 2008). Then, in the first stage a layer of Plastazote poly foam with a thickness of 4 mm finds forming and shaping character by exposure to heat, heated and drawn on the form provides the contact area of insole with foot and pulled fingertips. Second, for property of shock absorption and or flexibility, material properties and the choice was added as a second layer (Hsu et al., 2008). For this purpose polypropylene thermoplastic sheet with a thickness of 2 mm on the shape of a positive mold and edges to create a buffer layer with the walls almost similar UCBL orthoses were cut. The inner edge to the extent that does not impair the patient's comfort and long outer edges were cut as short as possible. In Orthotics UCBL internal and external walls of the heel, included the heel bone to restrict movement on the fixed valgus (Leung et al., 1998). In this study the walls of this section to the extent that cover only surface of the heel were short. Creating this change had been in order to eliminate interference from walls to control pronation and easily placed inside the shoe orthotics. The lower edge of the plantar surface of the foot orthosis buffer layer is proximal to the metatarsal heads, respectively.

Test protocol

Each person was asked to participate in all phases of the experiment (without insoles, custom insole Slipper casts and custom circumferential wrap), without being aware about the status of forces, walk with normal and similar speed and each steps complete a cycle of walking. In order to determine whether anticipated changes in the posterior part of foot is related to type of orthoses or the type of shoes, was used several pairs of the same standard sandals in the size of each individual's foot size is configurable on additional paragraphs foot was equipped for the walk with and without orthotics . It was asked from each person to walk 10 minutes to get used to the insoles. Finally, after a person declared his readiness to test, experiment started. The test was randomized for each participant. In the first stage, person was asked to walk bare foot and with an interval of 5 minutes, the second phase was started. This time interval in order to avoid fatigue and its effects on walking test was taken. In this stage insole made of Slipper cast molded type or insoles made of circumferential wrap molded type was placed inside the shoe, subjects were asked to perform prior steps. After recording the data in all phases of the experiment, the data obtained from all three phases of each individual were collected in a file.

Statistical analysis

SPSS version 20.0 was used for statistics analysis. The normal distribution of variables was tested through K-S test. In order to understand the difference between each pair of means between groups, Bonferroni test and investigate the pure effects of the use of insoles with two different molding methods (Slipper casts and circumferential) and bare foot on the position of the ankle joint, analysis of variance with repeated measures was used.

Results

The analysis of data (Table 1) indicated that there was no significant difference between the maximum mean deviation angle and speed of aversion in three states. Although little difference between the average maximum deviation aversion in three states were observed but statistical analysis of the data showed that molded insoles (slp = 6.6 (4.66), cir = 7.7 (3.13)) and the state of without insole (norm = 9.7 (6.03)) wasn't significantly different (P <0.05). Thus it can be stated that there was no significant difference between the mean scores of subjects in three states at a maximum deviation of aversion. In addition, using molding method of Slipper casts and circumferential had no immediate effect on the reduction maximum mean of the of aversion angle of foot ankle compared bare foot. Also maximum speed of aversion in the ankle was not affected by any of insoles molding techniques and no significant change was observed. According to the results of statistic intergroup test of the all parameters (mean of maximum deviation of aversion- mean of maximum angle of aversion- mean of maximum speed of aversion) in each three assumed situation (norm-slp-cir) there was not a significant difference (P = 0.001).

Table 1. The maximum value of the average deviation, angle and velocity of eversion in each case with molded insole methods slipper casting and Circumferential wrap compared to the situation without the insoles.

	Flexible Flat Foot individuals (n=10)			
	Dependent variables			
Independent variables	Norm	Slp	Cir	P_{Value}
Max. deviation of Ankle Evn	9.7(6.03)	6.6(4.66)	7.7(3.13)	0.149
Max. Angle of Ankle Evn	-5.7(3.58)	-3.9(5.96)	-5.4(5.96)	0.466
Max. Vilocity of Ankle Evn	0.8(0.49)	0.8(0.49)	0.6(0.3)	0.611

P<0.05; norm: only shoe without the insoles; slp: Slipper casting Technique; cir: Circumferential wrap Technique

Discussion and Conclusion

The aim of this study was to investigate the immediate effect of two molding methods of slp and cir position of the ankle joint in the frontal plane in young people with flexible flat foot. The results show that the use of molding slp and cir, had no immediate effect on reducing the mean of maximum angle of aversion of the ankle compared to the shoe without insole, many studies reported lack of control of the maximum aversion angle and aversion speed of assistant and preventive insoles. For example, Leung et al. (1998) specifically about molding method of slp, Zifchock et al (2008) and Davis et al (2008) as well as custom and non-custom insoles in separate studies on the rate of change of the maximum angle and speed of aversion compared with no insole in healthy people had reported very little, but this little change in the potential long-term effect on reported foot kinematics (Leung et al., 1998). Also this result was similar to Chen et al (2009) that reported custom insoles had no significant effect on the maximum aversion angle of foot ankle (Chen et al., 2009), and all of those studies had same results with the current study, although these studies specially were not indicated the type of molding, methods and tools used, but maximum angle and speed of aversion affected by none of used insoles in these studies. In other words, it can be stated that the maximum aversion deviation in the ankle not immediate affected of molding methods and no significant change was observed. On the other hand, some studies reported the effect of custom and semi-custom orthotics on reducing the maximum aversion speed (Zifchock et al. 2008, McLean et al. 2006, Steele et al., 1998), that was inconsistent with the results of the current study.Also Simon Fuk-Tan and et al reported the effect of TCIFMP custom insole (having central arch, made of semi-rigid Plastvlyz and PPT) in a significant reduction of the valgus rare foot of people with flexible flat foot (Simon Fuk-Tan et al., 2015) And stated that pronation angle of patients when using sports shoes with insole significantly reach to normal state that is different with the results of current study. Perhaps the reason for this contradiction with the present study was the kind of sport shoes used in each of the studies. All those studies evaluated the immediate effect of different auxiliary and preventive insoles that is formed in a variety of forms and materials in different groups of subjects on the ankle joint kinematics especially in pronation control and maximum angle of ankle aversion, while Anders and et al in addition to the immediate effect, examined the long-term impact (4 months) of custom insoles (for certain construction methods were noted) in patients with chronic pain in the ankle pronation excessive pronation on the angle of an amount Navicular bone breakdown (Andreasen et al., 2013), that results showed no significant effect in reducing the immediate and long-term head pronation angle that was similar to result of current study.

Andreasen et al, examined the effect of insoles in 4 months and were achieved to that results, but this result can not reject long-term effectiveness of medical insoles (more than 1 year) categorically because that study had limitations and the fundamental differences with other studies that can have different effects under different circumstances. For example, perhaps creating physiological changes in the structure and anatomy of the plantar and ankle as a result of external intervention (passive agent) within 4 months is not specified. There is a weak communication between the lower angle of aversion and use of insoles. It seems that the use of insoles in reducing aversion angle for a long time (almost a year) have a significant and meaningful impact. In addition, the difference in the results of different studies can be examined from several aspects. Some cited studies have been done on healthy subjects and some studies on people with flexible flat foot. Healthy young people may be more adaptive to the modified insole compared to people with flat foot. Although the arch structure was not evaluated in the present study, however this property may affect the responses of those to variables of the posterior foot. There is a possibility that abnormal structures of semi-custom foot orthoses are not implemented, and this point shows the requirement for further studies to determine what the scope of the foot for a custom orthotics are fit. But generally, the most studies have shown relative and absolute superiority of custom orthotics in controlling the movement of the hind feet and the comfort level compared to prefabricated orthoses (Davis et al., 2006; Leung et al., 1998; Mclean et al., 2006; Stacoff et al., 2007; Zifchock and Davis, 2008). In addition, other factors such as age, gender and individual differences may play an important role in people's walking pattern (Nester et al., 2003). In other words, each individual may have their own movement patterns, despite wearing different orthoses. Also, gender differences in mobility analysis seem to be due to differences in anatomy and different habits. On the other hand, some of these differences are due to those studies that were examined the effect of foot orthoses in different modes: static, while walking or running on a treadmill or on the ground (Mclean et al., 1998). Differences in used measurement instruments, features of the shoes used in various studies and different conditions in tests including the use of different materials with insole shoes, wedge acts on different parts of insole can be a source of difference effectiveness of the insoles. In addition to material and different quality, manufacturing methods, must not be ignored the angle and thickness of insole used in different studies. According, results and other studies that both methods can be reasonable way for molding the custom foot orthotics, but since intervention in this study was done immediately, it is recommended to evaluate the potential effects of long-term intervention.

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References

1. Chen Y, Lou S, Huang C, Su F. Effects of foot orthoses on gait patterns of flat feet patients. Clinical biomechanics. 2010; **25**(3):265-270.
2. Chuckpaiwong B NJ, Mall N, Queen R. The effect of foot type on in-shoe plantar pressure during walking and running. Gait Posture. 2008; **28**(3):405-11.
3. Simon Fuk-Tan Tang, Chien-Hung Chen, Chih-Kuan Wu, Wei-Hsien Hong, Kuan-Jung Chen, Chih-Kuang Chen. The effects of total contact insole with forefoot medial posting on rearfoot movement and foot pressure distributions in patients with flexible flatfoot. Clinical Neurology and Neurosurgery, 2015; **129**(Suppl 1):S8-11.
4. Davis l, Zifchock R, Deleo A. A comparison of Rearfoot motion control and comfort between custom and semi-custom foot orthotic devices. Journal of the American Podiatric Medical Association. 2008; **98**(5): 394-403.
5. Hsu D, Michael W, Fisk R, editors. AAOS Atlas of Orthoses and Assistive Devices. Philadelphia: Mosby, 2008.
6. McCourt F. To cast or not to cast? The comparative effectiveness of casted and non-casted orthoses. The Chiropodist. 1990; **45**(12): 43-239.
7. McCourt F, Bevans J, Cluskey L. Report of a survey on in-shoe orthoses provision. Journal of British Podiatric Medicine. 1994; **49**(5): 73-76.
8. Andreasen J, Mølgaard CM, Christensen M, Kaalund S, Lundbye-Christensen S, Simonsen O, Voigt M. Exercise therapy and custom-made insoles are effective in patients with excessive pronation and chronic foot pain—A randomized controlled trial. The Foot. 2013; 23(1):22-28.
9. Nester C, Van der Linden M, Bowker P. Effect of foot orthoses on the kinematics and kinetics of normal walking gait. Gait & posture. 2003; **17**(2): 7-180.
10. Maclean C, McClay Davis l, Hamill J. Influence of a custom foot orthotic intervention on lower extremity dynamics in healthy runners. Clinical Biomechanics. 2006; **21**(6): 30-623.
11. Leung A, Mak A, Evans J. Biomechanical gait evaluation of the immediate effect of orthotic treatment for flexible flat foot. Prosthetics and orthotics international. 1998; **22**(1): 34-25.
12. Landort K, Keenan A, Herbert R. Effectiveness of different types of foot orthoses for the treatment of planter fasciitis. Journal of the American Podiatric Medical Association. 2004; **94**(6): 542.
13. Sokhangoui Y, Asgari Ashtiani A. Orthopedic Shoe. Sarmadi Publication. First Edition. 2004.
14. Springett K, Otter S, Barry A. A clinical longitudinal evaluation of pre-fabricated, semi-rigid foot orthoses prescribed to improve foot function. Arthroscopy: The Journal of Arthroscopic and Related Surgery. 2007; **17**(4): 9-184.
15. Stacoff A, Quervain l, Dettwyler M, Wolf P, List R, Ukelo T, et al. Biomechanical effects of foot orthoses during walking. The Foot. 2007; **17**(3): 143-153.
16. Stell J, Buckley J. Controlling excessive pronation: a comparison of casted and non-casted orthoses. The Foot. 1998; **8**(4):210-214.
17. Williams D, McClay l, Hamill J, Buchanan T. Lower extremity kinematic and kinetic differences in runners with high and low arches. Journal of Applied Biomechanics. 2001; **17**(2):153-163.
18. Zifchock R, Davis l. A comparison of semi-custom and custom foot orthotic devices in high-and low-arched individuals during walking. Clinical Biomechanics. 2008; **23**(10):1287-1293.
19. Sokhangoui Y, Sokhangoui M. Flat feet. Rad No Andish Publication. 2006; P:67.

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